Microstructure and luminescent properties of transparent $MgAl_2O_4$ nanoceramics

A.N. Kiryakov[1], A.F. Zatsepin[1], V.A. Pustovarov[1], T.V. Dyachkova[2]

[1]*Ural Federal University, 620002, Yekaterinburg, Russia*
e-mail: arseny.kiriakov@urfu.ru

[2]*Russian Academy of Sciences Urals Branch Institute of Solid State Chemistry, 620137, Yekaterinburg, Russia*

Transparent ceramics of aluminum-magnesium spinel (AMS) are actively investigated. Optical transparent window from 0.2 to 5 microns, heat resistance, corrosion resistance, radiation resistance allow the use of such ceramics in such fields as laser technology, IR windows of homing missiles, armor, etc [1]. The inherent defectiveness, as well as morphological features of the surface, affect greatly lots of $MgAl_2O_4$ functional properties. The disadvantage of such ceramics is utilizing of LiF additives for transparency obtaining. Thermobaric treatment of AMS nanopowders allows to obtain transparent nanoceramics without LiF. Such ceramics are poorly investigated and of interest for practical applications.

Nanopowder of alumomagnesium spinel was obtained by reverse deposition method using aluminum and magnesium nitrates. Monophasic $MgAl_2O_4$ nanopowder was synthesized by quenching the resulting gel to 1000ºC. The thermobaric treatment was carried out at pressure of 5 GPa and 600°C temperature for 30 min. The powder was annealed preliminarily in vacuum at T = 500°C for 3 hours in order to desorb air.

The surface structure was studied using SIGMA VP scanning electron microscope (Carl Zeiss, Germany) and secondary electron detector (In-lens) in high vacuum at 3 kV accelerating voltage.

The photoluminescence spectra were measured by apparatus equipped with DFR-4 type double prism monochromators using a 400 W deuterium lamp and R-6358-10photomultiplier (Hamamatsu).

Investigated ceramics had a grain size ≤50 nm with spread not more than 20 nm according to SEM data (Fig. 1). Apparently, grain growth was inhibited by plastic deformation processes that were occurring during thermobaric processing [2]. Narrow grain size distribution can also be attributed to similar processes.

The photoluminescence spectra contained two 1.7 and 2.4 eV bands (Fig. 2). The 2.4 eV band was most effectively excited at photon energies of 3.9 eV, and the 1.7 eV band in the 4.85 eV region.

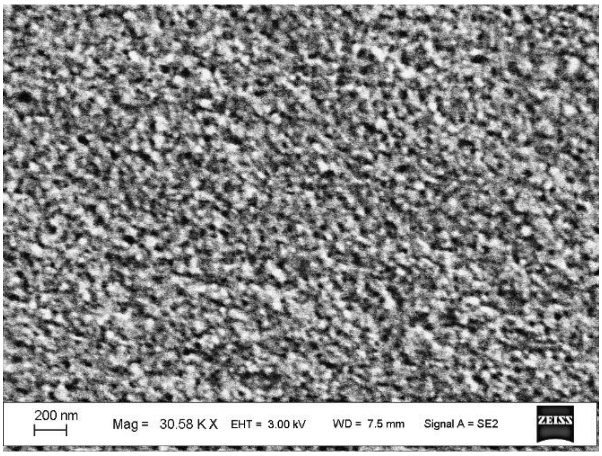

Figure 1. SEM of $MgAl_2O_4$ nanoceramics fragment.

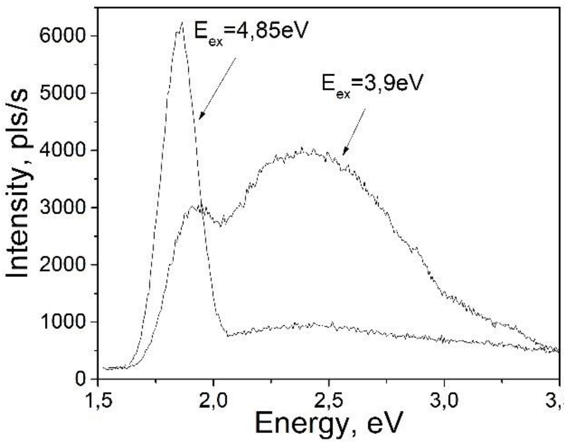

Figure 2. Luminescent spectra of nanoceramics measured at T=295K.

It is known that the Ti^{3+} impurity ions in alumomagnesium spinel contain a narrow band 1.73 eV with maximum excitation of 4.75 eV in PL spectrum [3]. Luminescence at 2.4 eV can be caused by Mn^{2+} ions impurity in tetrahedral position of magnesium [4]. It is interesting that this luminescence band has a half-width more than the one discussed in literature, and excitation energy does not coincide with the values known for single crystals. Additional EPR spectra measurements (not shown in this abstract) allowed us to conclude that there were Mn^{2+} impurity ions in studied ceramic (the presence of hyperfine splitting characteristic of Mn^{2+}).

Observed effect of luminescent bands broadening can be likely associated with grain size decrease [5]. The broadening of spectral lines is usually observed at a grain size of 10 nm or less because of emerging quantum constraints. Broadening was observed at 50 nm in studied samples which may be attributed to the size effect.

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